Lowrie, D. C. 1987. Effects of diet on the development of *Loxosceles laeta* (Nicolet) (Araneae, Loxoscelidae). J. Arachnol., 15:303-308.

EFFECTS OF DIET ON THE DEVELOPMENT OF *LOXOSCELES LAETA* (NICOLET) (ARANEAE, LOXOSCELIDAE)

Donald C. Lowrie[1]

Professor Emeritus
California State University, Los Angeles
Los Angeles, California

ABSTRACT

Spiderlings of *Loxosceles laeta* from a single egg sac were fed on two different diets: a varied one of fruit flies, mealworms and about ten meals of miscellaneous insects, and a limited one of fruit flies and mealworms only. About three times as many of those on the limited diet died before maturity (61%) as those on a varied diet (21%). Those on a varied diet had fewer molts to maturity, reached adulthood sooner, but lived longer as adults and had a longer total life span than those on the limited diet. They also grew to a larger size than ones on the limited diet. Both populations showed similar survivorship curves, except for the limited diet group in which initial deaths during molting, before adulthood, showed 50% deaths in the first year. After that the survivorship curve was an A type like the other group. It is concluded that the diet of this spider and probably all spiders should include a variety of insects to approximate the best growing conditions.

INTRODUCTION

This study was undertaken to determine whether features of the life cycle of this spider, fed a limited diet of fruit flies and mealworm larvae, often fed to spiders in rearing studies, was adequate. Although the range of these spiders, *Loxosceles laeta*, is in South America, this study was done on individuals from a population which has lived in the Southern California area for an unknown length of time, certainly for many years. They are well established there and elsewhere in the world (Gertsch and Ennik 1983).

METHODS

About 130 spiderlings from one egg sac were reared and maintained until death. The female from which the spiderlings were obtained was collected in Sierra Madre, in the San Gabriel Valley of the Los Angeles area in June 1969. She was immature and molted on 12 July and again, to become mature, on 1 November. She was mated to a male which was captured as an immature in July 1969. He became adult on 8 October. On May 1st 1970 a successful mating occurred and an egg sac was laid on 4 June 1970. Young spiderlings emerged on

[1]Present address: 117 Country Club Gardens M.H.P., Santa Fe, NM 87501.

27 July. They were placed separately in plastic vials (about 40 cm^3 for spiderlings and 80 cm^3 for late instars and adults) with tight snap caps. None of them was given water, and seldom, except during feeding, was the cap removed. There was probably little water vapor in the vial (it was not tested) because room humidity was low, usually around 10% to 20%, and scarcely ever exceeded 30%. The spiders were kept at room temperature, ranging from 15° to 20°C, probably similar to the habitats in houses where they lived. The vials in which the spiders lived were stored on the same shelves in a cabinet at the lab or later, when I moved to Santa Fe, in my house where environmental conditions were not significantly different. Each spider in both groups was fed equal amounts of food at the same time irregularly every two to three weeks.

The group of 50 specimens reared on a varied diet was fed fruit flies, *Drosophila melanogaster* (mostly vestigial-winged mutants) when they were small, and larvae of the mealworm beetle, *Tenebrio molitor*, when they were larger. In addition, about ten meals during their lives consisted of miscellaneous insects (a mixture of insects from sweeping vegetation outside—one that consisted of flies, bugs and insects of a few other orders).

Another group of 80 spiders were fed *only* fruit flies and mealworms. Three spiders were accidentally killed while being fed so the total number in each group at the end was 48 and 79 respectively. The reason for the unequal numbers in the two groups is unimportant to the result, as the numbers were sufficient to document differences between spiders. Sex, size and any other variables were randomly distributed in the two samples. Individual records of when spiders were fed, when they molted, when they became mature and what each carapace width was each time were made. Summaries are shown in the tables.

Somewhat over a year after those that lived had reached maturity (two to three years), rather than preserving them, I ceased feeding them as I had been doing. Although this last part of the study was not in my original plans, it transpired that they became a significant part of the results. For two and a half years (December 1973 until 22 July 1976) they were all fed one mealworm each on four different occasions at irregular intervals (three to ten months). After 22 July I ceased feeding them entirely. By that time only 23 females and no males were still alive. Some of the results of the starvation of the 14 females on a varied diet have already been published (Lowrie 1980). This report adds the results of the growth of the nine starved females on a limited diet.

RESULTS AND DISCUSSION

Longevity and development.—Of the total of 127 spiderlings that were studied until their death, on the varied diet 21% (10 of 48) died at various times, usually while molting, before reaching maturity. This whole group had a mean life span of 236 days, a range of 166.5 to 306.3 days (95% confidence level). Of the 79 on a limited diet, 61% (48 of 79) died before adulthood. Only two meals of miscellaneous insects had been fed those on a varied died during their growth as immatures out of about 75 total meals. Those on a limited diet had a mean life duration of 324 days, a range from 297 to 351 days (95% confidence level), nearly 50% longer than those on a varied diet. Of the two populations, those on a restricted diet showed a significantly greater number of deaths than those on a varied diet ($P < 0.01$).

Table 1.—Longevity of male *Loxosceles laeta*. Twenty-two were fed on a varied diet (V), while 14 were fed on a limited diet (L). Asterisk refers to the number of molts *after* emergence from egg sac. $N = 36$.

	No. of Molts*		Days to Adulthood		Days as Adult		Total Days of Life		Carapace Width	
	V	L	V	L	V	L	V	L	V	L
Mean	7.3	8.0	819	930	598	200	1417	1132	3.5	3.3
SD	0.77	0.78	194	213	197	167	97	295	0.17	0.23
SE	0.16	0.21	41	57	42	45	21	79	0.04	0.06
95%	6.9	7.5	733	807	511	104	1374	961	3.4	3.2
confidence	to	to	to	to	to	to	to	to	to	to
interval	7.6	8.4	905	1053	685	297	1460	1303	3.6	3.5
Sample	6	7	547	714	227	24	1101	817	3.2	3.0
range	to	to	to	to	to	to	to	to	to	to
	9	9	1200	1227	912	635	1494	1500	3.8	3.7
t-test (34 degrees of freedom)	2.682		1.615		6.260		4.200		2.701	
Significance level	< 0.02		< 0.11		< 0.001		< 0.001		< 0.02	

Longevity of adults.—Males (Table 1) are significantly shorter lived than the females (Table 2). Both feeding regimes resulted in virtually all males being dead by the time the first female died. Tables 1 and 2 show (95% confidence level) that males on a limited diet died in a shorter time (mean of 1132 days) than those on a varied diet (mean of 1417 days). Females on limited diets lived a shorter time (mean of 1844 days) than those on varied diets (mean of 2507 days). Student's t-test corroborates the significance of the differences (Tables 1 and 2).

Although females take only a slightly shorter time to reach adulthood (762 days with varied diets; 819 days for males) they lived as adults almost three times as long as the males (males 598 days; females 1745 days). Galiano (1967) reared *Loxosceles* to maturity in an average of 316 days for females and 406.5 days for males. Further life cycle work by Galiano and Hall (1973) indicates a slightly longer time to maturity than in her 1967 study: 328.5 days to maturity for females and 454.7 days for males. Likewise for the number of days as an adult and total life span. Their figures for females indicate 1547.4 days as adults for virgin females and a total of 1893.8 total days of life, while males who had not copulated lived for 640.9 and 1155.4 days respectively. These data show lengths of life consistently shorter than mine and probably significantly so.

I have no explanation for this shorter maturing time for the Argentinian specimens in contrast with the Californian. Possible explanations are that this California group was a different population which has been living in a different locality for an unknown time and that it may have evolved different growth characteristics. Rearing conditions (temperature, humidity, frequency of feeding and type of prey, etc.) were also somewhat different and could be responsible for the differences.

During the period of starvation the females on a limited diet lived only half as long as those on a varied diet (244 days versus 453 days). The two samples indicate that the differences between the two populations were highly significant ($P < 0.01$). The survivorship curve (Fig. 1) shows the growth curve of those on a

Table 2.—Longevity of female *Loxosceles laeta*. Sixteen were fed on a varied diet (V), while 17 were fed on a limited diet (L). Asterisk refers to the number of molts *after* emergence from egg sac. $N = 33$.

	No. of Molts*		Days to Adulthood		Days as Adult		Total Days of Life		Carapace Width		No. Days Life (Starvation)	
	V	L	V	L	V	L	V	L	V	L	V	L
Mean	7.5	8.1	762	900	1745	1074	2507	1844	4.0	3.65	453	244
SD	0.52	0.70	104	211	327	641	300	720	0.37	0.55	171	148
SE	0.13	0.17	26.5	54	82	166	75	175	0.09	0.13	46	49
95%	7.2	7.8	707	784	1571	908	2348	1474	3.8	3.4	354	130
confidence	to	to	to	to	to	to	to	to	to	to	to	to
interval	7.8	8.5	818	1017	1919	1240	2667	2215	4.2	3.9	551	357
Sample	7	7	669	700	1028	38	1746	815	3.3	2.95	219	7
range	to	to	to	to	to	to	to	to	to	to	to	to
	8	9	973	1431	2108	1836	2872	2646	4.45	4.4	755	499
t-test (34 degrees of freedom)	2.797		2.320		3.755		3.413		2.207		3.482	
Significance level	< 0.01		< 0.05		< 0.001		< 0.01		< 0.05		< 0.01	

varied diet to be the type A curve of Allee et al. (1949, p. 300); those that live with a minimum of mortality in the first part of their life cycle and then die within a short time at the end of their life cycle. The initial death rate of those on a limited diet, however, fits the type C curve better with the initial death rate high, in the first part of the curve. However, after maturity it fits the type A curve quite well. It might be noted that longevity in this study is probably longer than it would be in a wild population because predation and parasitism were non-existent because the spiders were in enclosed vials where these processes could not affect them. Also, food was readily available and probably more than it would have been in the wild.

Number of molts to adulthood and size (Carapace Width) differences.—Those spiders living on a limited diet showed a slightly, but significantly, greater mean number of molts necessary to reach adulthood. Although the actual number of molts after emergence from the egg sac is similar for males and females, statistically their differences are significant ($P < 0.02$). The conclusions are that those on restricted diets are slower to attain maturity, averaging nearly one more molt to adulthood. Galiano's (1967) specimens showed the same range of number of molts.

Carapace width as a measure of size is used because Hagstrum (1971) has shown that this structure does not vary in measurements significantly even if taken at various times between molts. The average female on a varied diet had a carapace width about 10% larger than the female on the limited diet. In the male the increase is only a little over 5%. The differences between carapace widths of those on a restricted diet versus limited diet is significant (female $P < 0.05$, male $P < 0.02$). The "well-fed" varied-diet individuals consistently grow to a significantly larger size. This might be expected since with better nutrition better growth is typically the case in animals.

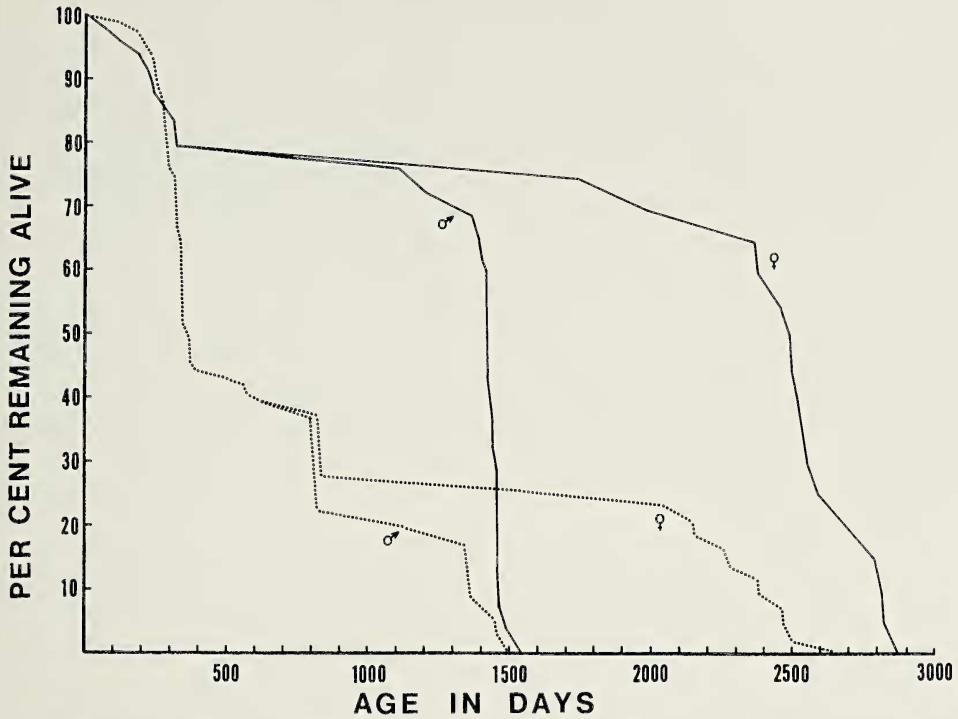

Fig. 1.—Survivorship curve of *Loxosceles laeta*. Dotted line = spiders on a restricted diet. Solid line = spiders on a varied diet.

CONCLUSIONS

Why those on a varied diet died sooner than the immatures on a restricted diet was not determined. It probably is related to the longer life as immatures with more molts which are critical periods when death usually occurs. This effect resulted in spite of the varied diet spiderlings having had only two meals of miscellaneous insects out of 50 to 75 meals during this period. Similarly those on a more varied diet had fewer molts, reached maturity sooner, lived longer as adults and had a longer life span than those on a restricted diet. The adult size of those on a varied diet was greater and starved adults on a varied diet lived nearly twice as long as those on a limited diet.

The basic conclusions seem clear that in this species a varied diet, even though it varies by only a few meals of miscellaneous insects, is a better, more healthy, probably more adequate diet than only mealworms and fruit flies. In any experiment involving rearing or maintaining *Loxosceles laeta* and probably other species of *Loxosceles*, and possibly any species of spiders, a varied diet should be provided to ensure that all necessary nutrients are present. According to Brues (1946), Patton (1963) and Wigglesworth (1947), these results would seem to fit expectations in diets in that most diets of insects must contain a certain spectrum (varying with the insect) of carbohydrates, fats, proteins, vitamins, minerals, etc. Spiders would not be expected to differ in this general regard.

ACKNOWLEDGMENTS

I acknowledge the aid of Dr. Findlay Russell and the University of Southern California Medical School for funds and early rearing expenses. I would also like to thank Dr. Monte Lloyd of the University of Chicago for reading the manuscript and producing the survivorship curves and generally improving the manuscript.

LITERATURE CITED

Allee, W. C., A. Emerson, O. Park, T. Park and K. P. Schmidt. 1949. Principles of Animal Ecology. W. B. Saunders, Philadelphia, Pa., 837 pp.

Brues, C. T. 1946. Insect Dietary. Harvard Univ. Press, Cambridge, Mass., 466 pp.

Galiano, M. E. 1967. Ciclo biológico y desarrollo de *Loxosceles laeta* (Nicolet, 1849). Acta Zool. Lilloana, 23:432-464.

Galiano, M. E. and M. Hall. 1973. Datos adicionales sobre el ciclo vital de *Loxosceles laeta*. Physis, 32(85):277-288.

Gertsch, W. J. and F. Ennik. 1983. The spider genus *Loxosceles* in North America, Central America, and the West Indies (Araneae; Loxoscelidae). Bull. American Mus. Nat. Hist., 175(3):263-360.

Hagstrum, D. W. 1971. Carapace width as a tool for evaluating the rate of development of spiders in the laboratory and the field. Ann. Entomol. Soc. Amer., 64(4):757-760.

Lowrie, D. C. 1980. Starvation longevity of *Loxosceles laeta* (Nicolet) (Araneae). Entomol. News, 91(4):130-132.

Patton, R. L. 1963. Introductory Insect Physiology. W. B. Saunders Co., Philadelphia, Pa., 245 pp.

Wigglesworth, V. B. 1947. The Principles of Insect Physiology. Methuen & Co., Ltd., London, 434 pp.

Manuscript received July 1984, revised February 1987.